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Episodic and semantic memory in bilingual and monolingual children

REZA KORMI-NOURI[1,2], SADEGHEH MONIRI[2] and LARS-GÖRAN NILSSON[2]

[1]*Department of Psychology, University of Tehran, Iran*
[2]*Department of Psychology, Stockholm University, Sweden*

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Although bilinguality has been reported to confer advantages upon children with respect to various cognitive abilities, much less is known about the relation between memory and bilinguality. In this study, 60 (30 girls and 30 boys) bilingual and 60 (30 girls and 30 boys) monolingual children in three age groups (mean ages 8.5, 10.5 and 12.5 years) were compared on episodic memory and semantic memory tasks. Episodic memory was assessed using subject-performed tasks (with real or imaginary objects) and verbal tasks, with retrieval by both free recall and cued recall. Semantic memory was assessed by word fluency tests. Positive effects of bilingualism were found on both episodic memory and semantic memory at all age levels. These findings suggest that bilingual children integrate and/or organize the information of two languages, and so bilingualism creates advantages in terms of cognitive abilities (including memory). Some sex differences were also found in episodic memory but not in semantic memory. This episodic memory difference was found with younger children.

Key words: Bilingualism, episodic memory, semantic memory, action memory, verbal memory, children.

Reza Kormi-Nouri, PO Box 15655-354, Tehran, Iran. Email: reza_nouri@yahoo.com and rki@psychology.su.se

During the past 30 years, most cognitive development studies have shown a positive influence of bilingualism. That is, learning a second language in childhood is associated with an increase in cognitive abilities and mental processes relative to those of monolingual children (for reviews see Diaz & Klingler, 1991; Francis, 1999a). A list of bilingual advantages can be presented for cognitive abilities such as intelligence (e.g., Hakuta & Diaz, 1985; Hsieh & Tori, 1993), creativity (e.g., Diaz, 1985), analogical reasoning (e.g., Diaz, 1985), classification skills (e.g., Diaz & Padilla, 1985), problem solving (e.g., Bialystok, 1999), learning strategies (e.g., Bochner, 1996), and thinking flexibility (e.g., Lambert, Genesee, Holobow & Chartrand, 1993). This is in contrast to a traditional view assuming that bilinguality has a negative effect on cognitive development (e.g., Dornic, 1969; Long & Harding-Esch, 1977; Marsh & Maki, 1978) or that there is a delay in language development in bilingual children (Taylor, 1974).

Although recent cognitive studies have found a positive influence of bilingualism on children's cognitive abilities, we are still far from understanding the relationship between bilingualism and memory in children. With the reported increase in children's cognitive capacity, we might expect that memory ability will also increase. However, for short-term memory there are a few studies (Cook, 1979, 1981) showing that bilingual children have a shorter digit span than monolingual children. The reason for this memory deficit in bilinguals was claimed to be that short-term memory relies on sounds and phonological coding rather than processing (Cook, 1991). For long-term memory, which is more based on processing, to our knowledge, there has been no research comparing bilingual and monolingual children. It should be noted that, even for adults, there are more studies comparing performance with bilingual and unilingual lists than comparisons of bilingual and monolingual subjects (see Francis, 1999b).

It has been suggested that cognitive advantages in bilingualism are predominant in younger than older subjects (e.g., Ben-Zeev, 1977; Hakuta, 1987; Taylor, 1974) and children are more sensitive to processing rather than to phonological coding (Conrad, 1972; Cook, 1981). Thus, using child subjects is of special importance for investigating the effects of bilingualism on long-term memory. Furthermore, the use of children in three different age groups (means 8.5, 10.5, 12.5 years) makes it possible to see whether this effect appears early in the process of becoming bilingual or requires high levels of bilingual proficiency. That is, we can explore whether the effects of bilingualism are mediated by age (Hakuta, 1987).

It should be noted that there are different definitions of bilingualism (Francis, 1999a). In the present study, an intermediate definition of bilingualism, suggested by Grosjean (1992), was adopted: bilingualism is the regular use of two (or more) languages, and bilinguals are those children who need and use two (or more) languages in their everyday life.

For adult subjects, it has been demonstrated that recall of bilingual related words is poorer than unilingual related words, whereas no difference was found between bilingual and unilingual unrelated words (Lambert, Ingatow & Krauthamer, 1968; Nott & Lambert, 1968). In the present study, we used two types of long-term memory, episodic and semantic memory (Tulving, 1972, 1983, 1993; Tulving & Craik, 2000), to explore whether bilingualism would affect these two types of memory differentially. Episodic memory

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is about episodes or events from the personally experienced past and it exists in subjective time and space. Semantic memory relates to general information about the world (concepts, facts, ideas, categories, etc.) and has no concern with time and space. Episodic memory requires a conscious recollection of a previous event or a study episode and is a controlled process, whereas semantic memory does not require conscious recollection and is automatic (Tulving, 1985). In the present study, the distinction between episodic and semantic memory may allow us to test the idea that bilinguals who have better control of their language processing (Bialystok, 1986, 1999; Galambos & Hakuta, 1988) should perform better in episodic memory than in semantic memory.

In episodic memory, we used sentences (e.g., "read the book"; "give me the spoon"; "hug the doll") as to-be-remembered items. In the literature on memory and language, isolated words have been mostly used. The advantage of using sentences is that they are related more to natural and everyday language (Francis, 1996, 1999b; Hummel, 1993). Furthermore, in the present study, the sentences were learned either by action or by verbal encoding. Several studies have shown that action memory is superior to verbal memory for both adults (for reviews see Cohen, 1989; Engelkamp & Cohen, 1991; Nilsson, 2000) and children (Cohen & Stewart, 1982; Ratner & Hill, 1991). Since there is research (Paulston, 1975; Peal & Lambert, 1962) showing that the effect of bilingualism might be more observable for nonverbal (i.e., visual) tasks than for verbal tasks, it would be interesting to see whether this effect acts differently for verbal and action memory. It has been suggested that action memory produces an episodic integration between the action verb and the object of sentences, and that this episodic integration is the reason for the superior performance for action memory over verbal memory (Kormi-Nouri, 1995; Kormi-Nouri & Nilsson, 1998, 2001). It has also been suggested that, in bilinguals, two languages are integrated with each other and language integration seems to be the reason for the better cognitive performance of bilinguals compared with monolinguals (Francis, 1999a). If this is the case, we would expect to observe the effects of bilinguality more for action memory than for verbal memory.

Semantic memory was assessed by word fluency tests. Word production (such as letter or category fluency) is generally held to be an important aspect of semantic memory, due to the interdependence of linguistic codes and their related semantic concepts (Fernaeus & Almkvist, 1998; Nyberg *et al.*, 2001). As Estes (1974) suggested, word fluency tests provide an excellent means of finding out whether and how well subjects organize their thinking. Since letter fluency tests give the greatest scope to subjects seeking a strategy for guiding the search for words (Lezak, 1995), we used a letter fluency test in which the children's task was to generate words that begin with a given letter (S and B as initial letters). A search in Swedish and Persian lexicons revealed that the words beginning with these letters had intermediate frequencies in these two languages.

METHOD

Design

For episodic memory, a $3 \times 2 \times 2 \times 3 \times 2$ factorial design was used with three between-subject and two within-subject variables. Subjects were from three school grades (2, 4, and 6). In each grade there were two groups of subjects: monolinguals and bilinguals. Half of both bilinguals and monolinguals were boys and the other half girls. All subjects received three types of material (subject-performed tasks with real objects, subject-performed tasks with imaginary objects and verbal tasks) at encoding and two types of test (free recall and cued recall) at retrieval.

For semantic memory, the design was 3 (grade) $\times$ 2 (language) $\times$ 2 (sex) $\times$ 2 (letter).

Subjects

A total of 120 primary school pupils in Stockholm served as subjects. They were randomly selected from grades 2, 4, and 6 (40 subjects from each grade). Their ages ranged from 7 years and 9 months to 9 years and 4 months (mean 8.5 years) in grade 2, from 9 years and 7 months to 11 years and 4 months (mean 10.5 years) in grade 4, and from 11 years and 7 months to 13 years and 3 months (mean 12.5 years) in grade 6. In each grade, half the subjects were Swedish native speakers (monolinguals) and the other half were Iranian–Swedish bilinguals.

The bilingual and monolingual children were selected from the same state schools located in the central areas of Stockholm. It should be noted that, in Sweden (especially in central areas), there is not a big difference between immigrant and Swedish families with respect to socioeconomic status. Separate ANOVAs conducted for each grade showed no age difference between bilingual and monolingual children ($p > 0.40$). Each group of children was also matched with respect to sex (i.e., half were boys and half were girls). In line with the intermediate definition of bilingualism (Grosjean, 1992), all bilingual children had Iranian parents and spoke Persian at home (this was simply asked of the children, their Persian teachers at schools and their parents) but all received schooling in the Swedish language with Swedish teachers (except for 1 hour per week when they were taught Persian by Iranian teachers). All monolingual children had Swedish parents and spoke Swedish both at home (this was asked of children, their Swedish teachers at schools and their parents) and school.

To determine language ability, most researchers use self-rated proficiency or a self-rated relative proficiency scale (Francis, 1999a). For the present study, the self-rated proficiency of the bilingual children in both Swedish and Persian is shown in Table 1. According to this self-rating, it can be concluded that the bilingual children had at least a moderate level of proficiency in both languages (if we take rating 3 as a moderate level of proficiency), regardless of the age. It is also clear that the bilingual children rated themselves better in Swedish than in Persian, and this was more in reading and writing rather than in listening and speaking (these differences become gradually more pronounced from grade 2 to grade 6). In addition to the self-rating, knowledge of Swedish of both the bilingual and monolingual children was assessed by a standardized Swedish vocabulary test (SPIQ, Rydberg & Höghielm, 1974). In this test, children were shown a card with four pictures and asked to indicate (either verbally or by pointing) which picture best depicted a word given orally by the experimenter. A basal score was established and

Table 1. *Bilinguals' responses to the Language History Questionnaire*

	Grade 2	Grade 4	Grade 6
Mean number of residence years in Sweden	7.9	9.6	10.9
Mean number of hours of formal education in Persian	72.9	219.4	148.6
Mean self-rating (on a 6-point scale) of general ability in Swedish	4.15	4.55	4.50
Mean self-rating (on a 6-point scale) of general ability in Persian	3.20	4.00	3.40
Mean self-rating (on a 6-point scale) of different abilities in two languages:			
Swedish			
reading	3.90	4.50	4.25
writing	2.70	3.65	4.65
speaking	4.10	4.75	4.85
listening	4.20	4.75	4.85
Persian			
reading	3.75	3.75	3.00
writing	3.00	3.75	3.60
speaking	3.20	4.25	3.90
listening	3.85	4.70	4.25

Note: On the self-rated scale 6 = excellent, 1 = very poor.

Table 2. *Mean number of correct responses in the Swedish vocabulary test (SPIQ) for bilingual and monolingual children (maximum score = 60)*

	Grade 2	Grade 4	Grade 6
Bilingual	23.92	26.13	28.22
Monolingual	24.27	27.07	30.55

testing was continued through increasingly difficult items until the child made six errors in eight consecutive responses. These data are shown in Table 2.

An ANOVA performed for these data showed no overall difference between the bilingual and monolingual children with respect to Swedish vocabulary ability (monolinguals = 26.97 and bilinguals = 26.09, $p > 0.10$) (the maximum score was 60). It should be noted that the interaction between grade and language showed that, in grade 6, the monolingual children received a higher mean score than the bilingual children (30.55 vs. 28.22) ($p < 0.01$), whereas, in grades 2 and 4, there was no difference between the two groups of children ($p > 0.20$).

Materials

Forty Swedish sentences in imperative form (e.g., *läs boken*, "read the book"; *ge mig skeden*, "give me the spoon"; *krama dockan*, "hug the doll"), in two presentation orders, were used as to-be-remembered items. These were selected from a pool of items in a normative study (Kormi-Nouri, 1995). Half of the items were encoded as subject-performed tasks (SPTs), half with real objects (SPTo) and half with imaginary objects (SPTi), and the other half as verbal tasks (VTs). SPTs and VTs were counterbalanced across the two presentations of items. That is, all items appeared as SPTs and VTs across subjects. Not more than two SPTs or VTs were allowed to appear in succession.

Procedure

Each subject was tested individually. The experiment was conducted in Swedish. The items were presented using a tape recorder, one by one, at a rate 7 s per item with a 3 s interval between the items. The subjects were instructed to remember whole items for subsequent recall tests.

For VTs, children were instructed to listen to and repeat the items aloud, whereas for SPTs they were instructed to listen to and perform the action indicated by the items. Half of the SPTs were performed with real objects given by the experimenter during the presentation of items and hidden immediately after the presentation, and for the other half the children imagined the objects. The experimenter said "sentence" before presenting the VTs and "action with object" or "action without object" before presenting the SPTs. Before starting the experiment, each subject received six example items (not presented in the list) to practice.

After the presentation of the list of items, the subjects were given a word fluency test in which they were asked to write down as many Swedish words (except names) as they could that began with the letter "S" or "B", in 2 min.

Then, the subjects received a free recall (FR) test to remember as many VTs and SPTs as possible for 7 min. After the FR test, the subjects were given another word fluency test (S or B) for 2 min.

Then, they received a cued recall test (CR). Half of the subjects were cued by verbs, whereas the other half were cued by nouns.

After the CR test, the subjects were given a standardized Swedish vocabulary test (SPIQ), specially constructed for determining language ability of Swedish primary and high school students.

The experiment was ended by all subjects completing the Language History Questionnaire, to rate their lingual experience and skills on a scale of 1–6 (6 = excellent, and 1 = very poor). It should also be noted that bilingual children carried out two additional word fluency tests in Persian with the same initial letters (i.e., S and B), one before and one after the Swedish vocabulary test. The entire experiment lasted approximately an hour.

RESULTS

Both strict and lenient scoring systems were used in FR and CR data. In the strict scoring, responses were accepted as correct only if they were exactly the same as in the study list. In the lenient scoring, responses were accepted as correct if they had the same meaning as the original items (e.g., move and take away, press and push, shirt and blouse,

Table 3. *Mean proportion of items correctly recalled by children in free recall across language and encoding conditions*

	SPTo	SPTi	VT
Grade 2			
Bilingual	0.34	0.18	0.08
Monolingual	0.29	0.19	0.05
Grade 4			
Bilingual	0.37	0.26	0.07
Monolingual	0.36	0.21	0.06
Grade 6			
Bilingual	0.39	0.28	0.09
Monolingual	0.37	0.29	0.06

Table 4. *Mean proportion of items correctly recalled by children in cued recall across language and encoding conditions*

	SPTo	SPTi	VT
Grade 2			
Bilingual	0.67	0.45	0.32
Monolingual	0.57	0.48	0.33
Grade 4			
Bilingual	0.67	0.61	0.27
Monolingual	0.55	0.53	0.29
Grade 6			
Bilingual	0.73	0.58	0.25
Monolingual	0.66	0.64	0.30

bag and basket). The lenient scoring was used because the present study was related to children's memory and language, and so the gist of information should be more emphasized than the exact words used in the study list. Since few differences resulted from the use of these two types of scoring, only strict scoring data are reported here. Where appropriate, differences between these two types of scoring are discussed.

FR analysis

The results of FR are shown in Table 3. A 3 (grade: 2, 4, and 6) × 2 (language: bilingual and monolingual) × 3 (type of encoding: SPTo, SPTi, and VT) ANOVA was conducted to evaluate the FR data. Using strict scoring, although the bilingual children recalled better than the monolingual children (0.23 vs. 0.21), the ANOVA showed no significant difference between the two ($p > 0.10$). In the lenient scoring, however, the difference between the bilingual and monolingual children reached significance (0.29 vs. 0.26), $F(1, 114) = 3.84$, $MSe = 0.09$, $p < 0.05$. There was no interaction between language and type of encoding ($p > 0.70$). The main effect of grade was significant, $F(2, 114) = 4.76$, $MSe = 0.10$, $p < 0.05$. A Tukey test indicated that children in grade 6 (0.25) recalled better than children in Grade 2 (0.19). There was no difference between grades 2 and 4 or between grades 4 and 6. Type of encoding was also significant, $F(2, 228) = 195.82$, $MSe = 2.45$, $p < 0.001$, indicating that SPTos (0.35) were recalled better than SPTis (0.23), which, in turn, were recalled better than VTs (0.07). The interaction between grade and type of encoding showed that SPTs (both with real and imaginary objects) were recalled better in higher grades than in lower grades, but this was not observed for VTs; this interaction effect reached significance only for the lenient scoring, $F(4, 228) = 2.62$, $MSe = 0.04$, $p < 0.05$.

When sex was added as a variable of interest to this analysis, it was found that girls recalled better than boys (0.23 vs. 0.20), $F(1, 108) = 4.57$, $MSe = 0.10$, $p < 0.05$. The interaction effect between grade and sex, $F(2, 108) = 4.36$, $MSe = 0.09$, $p < 0.05$, indicated that boys' recall improved with age (grade 2 = 0.14; grade 4 = 0.21; grade 6 = 0.25), whereas there was no increase for girls' recall with age (grade 2 = 0.24; grade 4 = 0.23; grade 6 = 0.24).

CR analysis

The results of CR are shown in Table 4. A separate 3 (grade: 2, 4, and 6) × 2 (language: bilingual and monolingual) × 3 (type of encoding: SPTo, SPTi, and VT) ANOVA was performed for the CR data. The main effects of grade and language were not significant ($p > 0.10$), whereas type of encoding (SPTo = 0.64, SPTi = 0.55, VT = 0.30) was significant, $F(2, 228) = 179.04$, $MSe = 3.80$, $p < 0.001$. The interaction between language and type of encoding, $F(2, 228) = 6.19$, $MSe = 0.13$, $p < 0.01$, indicated that bilingual children had better recall only of SPTos than monolingual children. This effect was not observed for SPTis and VTs. The interaction between grade and type of encoding, $F(4, 228) = 5.65$, $MSe = 0.12$, $p < 0.01$, showed that children in higher grades had better recall of SPTos and SPTis but not VTs.

With the addition of the sex variable to the analysis, although the main effect of sex was not significant ($p > 0.70$), the interaction between grade and sex was significant, $F(2, 108) = 3.19$, $MSe = 0.13$, $p < 0.05$. This interaction indicated that boys' memory increased with age (grade 2 = 0.44; grade 4 = 0.50; grade 6 = 0.56), whereas no difference was observed in girls' memory (grade 2 = 0.50; grade 4 = 0.48; grade 6 = 0.49). Furthermore, in grade 2 girls recalled better than boys (0.50 vs. 0.44), whereas in grade 6 boys recalled better than girls (0.56 vs. 0.49) (there was no sex difference in grade 4).

Word fluency analysis

The results of Swedish and Persian word fluency tests are shown in Table 5. A 3 (grade) × 2 (language) × 2 (letter) ANOVA conducted on the Swedish word fluency data showed that all three main effects were significant. Children in grade 6 (17.44) recalled more words than children in

Table 5. *Mean number of Swedish and Persian words (beginning with the letters "S" and "B") recalled by children in 2 min across language conditions*

	Swedish		Persian	
	S	B	S	B
Grade 2				
Bilingual	12.75	12.00	9.25	9.80
Monolingual	11.85	10.45	–	–
Grade 4				
Bilingual	15.54	13.55	10.65	11.30
Monolingual	14.80	14.40	–	–
Grade 6				
Bilingual	20.95	17.50	11.95	11.15
Monolingual	17.16	14.15	–	–

grade 4 (14.57), who, in turn, recalled more than children in grade 2 (11.76), $F(2, 114) = 27.89$, $MSe = 643.82$, $p < 0.001$. Bilingual children recalled more words (15.38) than monolingual children (13.80), $F(1, 114) = 6.48$, $MSe = 149.56$, $p < 0.05$. Words beginning with "S" (15.51) were recalled better than words beginning with "B" (13.68), $F(1, 114) = 24.60$, $MSe = 201.62$, $p < 0.001$. This latter effect was significant only in grade 6 ($p < 0.001$), not in grade 4 ($p = 0.07$) or grade 2 ($p > 0.10$). There was a tendency for an interaction between grade and language, $F(2, 114) = 2.92$, $MSe = 67.34$, $p = 0.06$, indicating that the effect of bilinguality was significant only in grade 6 ($p < 0.01$) and not in grade 2 ($p > 0.20$) or grade 4 ($p > 0.90$).

The addition of the sex variable into the analysis showed no significant difference between girls and boys ($p > 0.20$) and no interaction effects between sex and the other variables ($p > 0.30$).

A separate 3 (grade) × 2 (sex) × 2 (type of letter) ANOVA conducted on the Persian word fluency data showed that bilingual children recalled better in grades 4 and 6 than in grade 2 (there was no difference between grades 4 and 6), $F(2, 54) = 3.69$, $MSe = 70.06$, $p < 0.05$. There was no sex difference ($p > 0.50$) and no difference between Persian words beginning with "S" and "B" ($p > 0.10$).

For bilingual children, a comparison between Swedish and Persian word fluency showed that their Swedish vocabulary was superior to their Persian vocabulary. An ANOVA for amount recalled of Swedish and Persian words for bilingual children confirmed this superiority (Swedish = 15.47, Persian = 10.77), $F(1, 57) = 80.11$, $MSe = 1325.400$, $p < 0.001$. The ANOVA also showed an interaction between grade and language (Swedish vs. Persian), $F(2, 57) = 6.80$, $MSe = 112.51$, $p < 0.05$, indicating that this superiority was more pronounced in grade 6 (7.43) than in grades 2 (3.10) and 4 (3.57). That is, in line with the subjects' self-rating, as bilingual children get older and proceed to higher grades, their Swedish vocabulary improved much better than (more than double) their Persian vocabulary.

DISCUSSION

Recent cognitive studies have shown that knowing a second language extends rather than diminishes the individual's capabilities. That is, learning a second language increases the normal capacity of individual and so confers a benefit rather than creating a problem. Thus, a person who has two languages has access to situations and experiences that are not available to a monolingual person. Cognitive research has shown the positive effects of bilinguality on intelligence (e.g., Hakuta & Diaz, 1985; Hsieh & Tori, 1993), creativity (e.g., Diaz, 1985), reasoning (e.g., Diaz, 1985), classification skills (e.g., Diaz & Padilla, 1985), problem solving (e.g., Bialystok, 1999), learning strategies (e.g., Bochner, 1996), and thinking flexibility (e.g., Lambert *et al.*, 1993). In line with this literature, the present study demonstrated that the positive effect of bilinguality can also be true for children's long-term memory. In both episodic and semantic memory, bilingual children recalled better than monolingual children. This effect was found in both free recall (restricted to the lenient scoring) and cued recall (restricted to the SPTo condition), although it was more pronounced in cued recall than in free recall. The reason for a stronger bilinguality advantage in CR than in FR, and with the lenient scoring than with the strict scoring, might be because FR is more difficult and effortful than CR, and so the bilinguality advantage can be observed when an easier memory task or scoring criteria are used. In the letter fluency test, as an indication of semantic memory, there was a clear bilingual advantage.

It should be noted that we had experimental control only over the selection of bilingual and monolingual children. They were selected from the same schools in the central areas of Stockholm and they were tested for their knowledge of Swedish. Because of practical limitations, we had no control over home conditions, and no information about parental education, occupation or cultural habits. It could be argued that these social factors might confound the effect of bilingualism. We certainly believe that memory and language are affected by social factors. The lack of experimental control over social factors is certainly unfortunate; on the other hand, however, social factors should hardly provide an advantage for the bilingual children who live as immigrants in Sweden. Despite the possibility of some socioeconomic disadvantage for bilingual children compared with monolingual children, the bilinguality advantage was observed in the present study. This suggests that socioeconomic situation is not a critical issue in this respect.

It has been suggested that the effect of bilingualism is due to the integration of two languages in children and the information of one language is intentionally or automatically accessible to the other language (Francis, 1999a). This gives an advantage (rather than disadvantage) to bilinguals to be more flexible in using the information of two languages in memory (Peal & Lambert, 1962). In episodic memory, the fact that the bilingualism effect was found for action memory

(SPTs with real objects) and not for verbal memory (VTs) confirms the integrative view of bilingualism. It has also been suggested that in action memory (especially with real movement and real objects) the information is highly integrated and that the superiority of action memory over verbal memory is due to a better episodic integration for action memory (Kormi-Nouri, 1995; Kormi-Nouri & Nilsson, 1998, 2001).

There is also a suggestion that language is an ancillary means of organizing information (Lambert *et al.*, 1968). The finding of a bilinguality effect for semantic memory (word fluency) provides support for the role of organization in bilinguality. In contrast to Peal and Lambert (1962) and in line with Diaz and Padilla (1985), the better recall of bilingual children over monolinguals found for both action memory (as a kind of nonverbal task) and semantic memory (as a kind of verbal task) indicated that type of material (verbal vs. nonverbal) is not per se an important issue but rather that the mental activity (such as integration or organization) is more important in the production the of bilinguality effect.

It is not clear whether the influence of processing in one language on processing in another language is automatic or deliberate. It has been suggested that, in action memory, implicit processing is added to explicit processing, whereas in verbal memory there is no such additional involvement of implicit processing (Nilsson & Bäckman, 1989). Semantic memory is also an uncontrolled recollection and automatic processing (Tulving, 1985). Thus, from the findings of better recall of bilingual children over monolingual children for action memory and semantic memory, it may be concluded that the bilingualism effect can be observed more under automatic or implicit processing than under deliberate processing. More research is needed to answer the question of automatic or deliberate processing in the relation between bilingualism and memory.

Kormi-Nouri (2000) found that, in action memory for adults, SPTs with imaginary objects were recalled as effectively as SPTs with real objects, reflecting that object is not of special importance in action memory. However, in the present study, in both FR and CR, children recalled SPTs with real objects better than SPTs with imaginary objects. Although, in the SPTi condition, physical movement alone could produce an expected enactment effect (compared with the VT condition) in both FR (0.16) and CR (0.24), in the SPTo condition the addition of physical object to physical movement could still increase the effect of enactment (FR = 0.28, CR = 0.34). These findings indicate that the role of objects in action memory might be different for children than for adults. That is, physical information of objects (e.g., color, size, shape) become more important for children than adults. An alternative explanation is that physical movement is less important for children than for adults (e.g., Ratner & Hill, 1991; Saltz & Dixon, 1982). This is because children may be less able than adults to perform actions (Wolf & Levin, 1972) or recode actions into words (e.g., Bruner, 1964). The comparison between the Kormi-Nouri (2000) study (only FR data for sighted subjects) and the present study (only FR data) provides some support for both explanations: In the SPTi condition, the effect of enactment was less for children (0.16) than for adults (0.20), whereas, in the SPTo condition, it was more for children (0.28) than for adults (0.23). That is, the superiority of SPTo over SPTi for children was partly due to the greater effectiveness of the object and was partly due to less effectiveness of movement. Since the two studies were not identical with respect to the lists and procedure, we cannot draw a proper conclusion at this point and more research is needed to answer this question.

Cohen and Stewart (1982) compared recall of words and SPTs for children in different age groups (9, 11 and 13 years old). They found an increase of word recall with age, but no age difference for recall of SPTs. Since younger children should have more difficulty in using mnemonic strategies than older children (e.g., Flavel, 1985), the lack of age difference for SPTs was attributed to a nonstrategic view of action memory, whereas the presence of age difference for words reflected strategic encoding. In line with the results of Ratner and Hill (1991), the present study revealed that action memory improved across developmental stages. Since, in FR, there was a floor effect for recall of verbal sentences, only CR data are discussed here. There was an increase of SPT (for both real and imaginary object) recall with age, although no age difference was found for VTs. This suggests that action memory involves strategic processes and even this can be more observable than the strategic processes involved in words.

In the present study, there was no interaction between sex and language (bilingual vs. monolingual). That is, the data pattern with respect to sex difference was the same for bilingual and monolingual children. The overall pattern is as follows. In episodic memory, girls recalled better than boys (in FR). In both FR and CR, boys' recall improved with age, whereas there was no increase for girls' recall with age. In semantic memory, no main effect for sex and no interaction between sex and age were observed.

Taken together, these findings suggest that, first, a sex difference can be observed for episodic memory and not for semantic memory. This is in line with the findings of Herlitz, Nilsson and Bäckman (1997), in which female adults outperformed male adults on the episodic memory tasks, but not on semantic memory tasks. Second, recall superiority of girls over boys appears in younger children but disappears in older children (older boys may even have a better memory performance). This may be because girls are ahead in cognitive development at an earlier age but boys reach the same level of cognitive ability at a later age. There is no clear explanation for gender differences, although both psychosocial and biological explanations have been proposed (Herlitz *et al.*, 1997). Psychosocial explanations emphasize on the

effects of environmental variables (e.g., interest, motivation), whereas biological explanations refer to brain organization in female and male. More still needs to be learned about this issue.

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